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2,127,210

GRINDING AND LAPPING MACHINE

Filed July 31, 1937

4 Sheets-Sheet 2

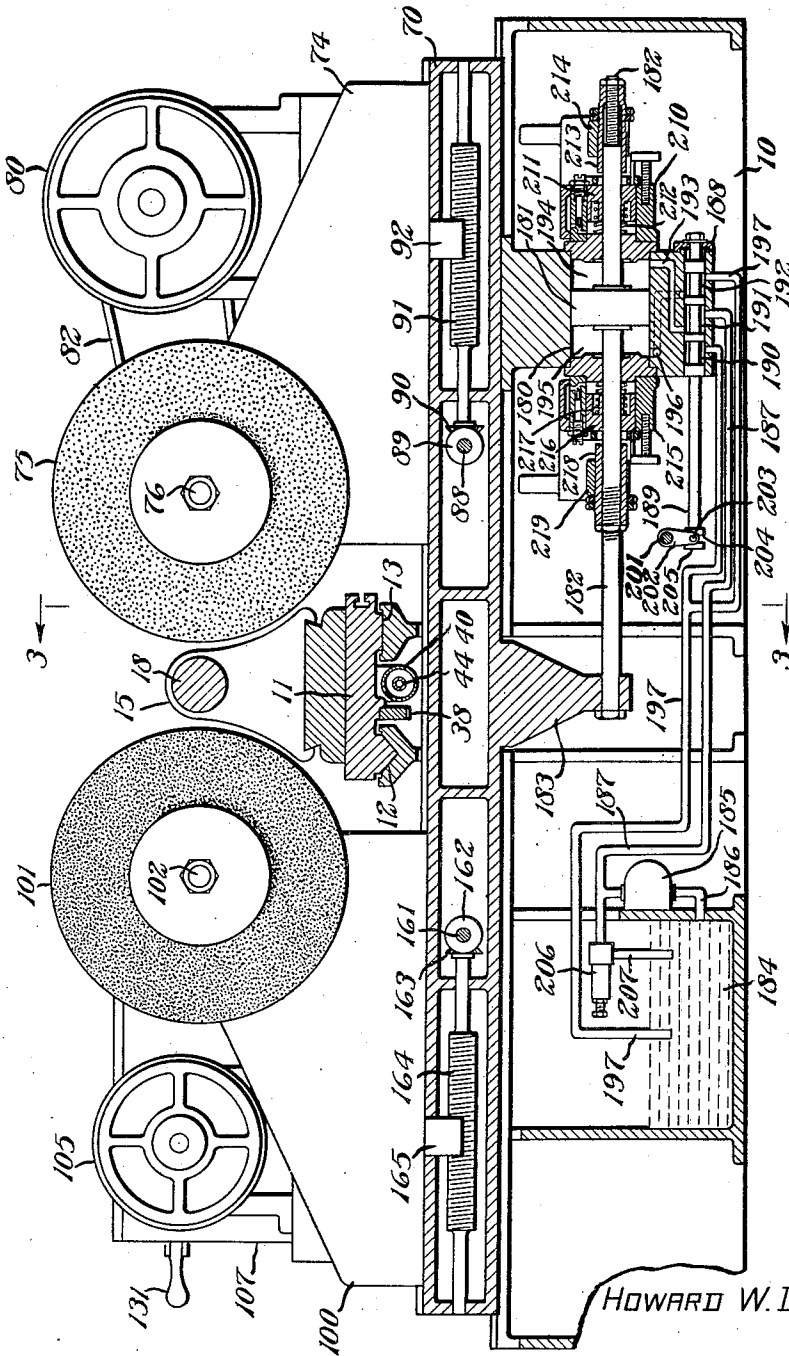


Fig. 2

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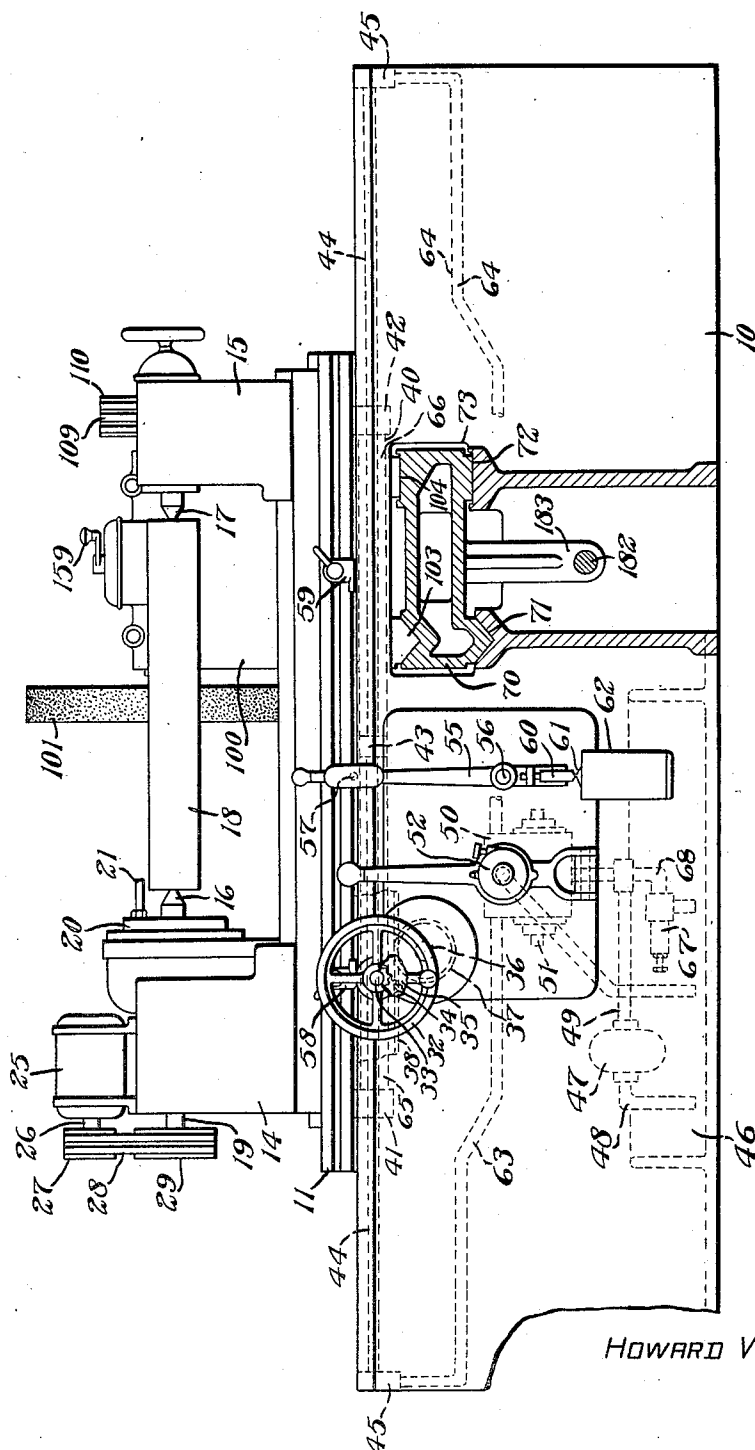
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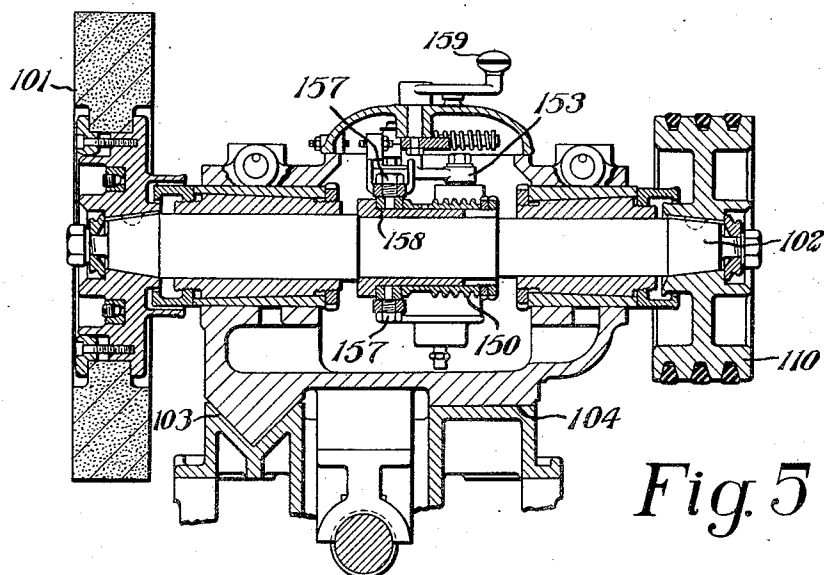
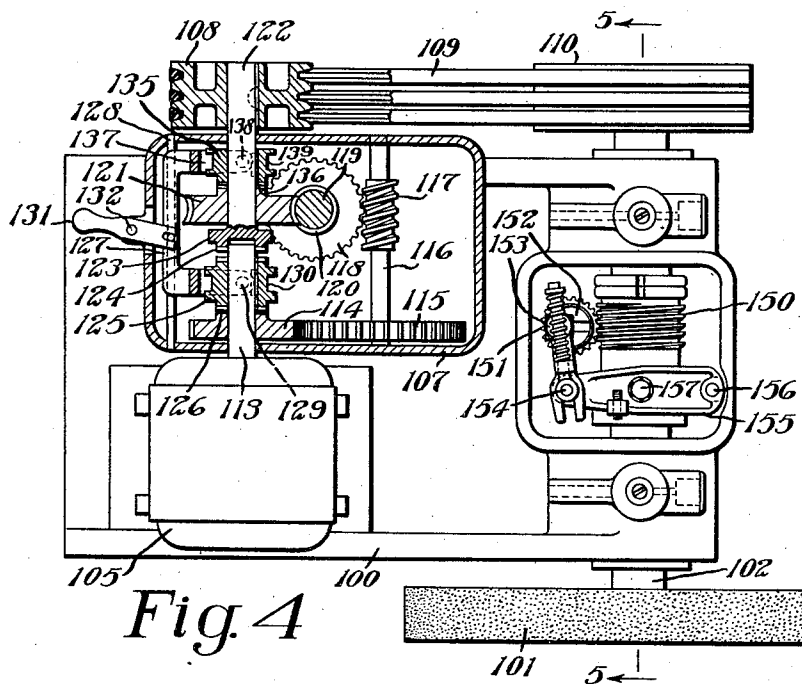
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4 Sheets-Sheet 4



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GRINDING AND LAPPING MACHINE

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Application July 31, 1937, Serial No. 156,768

16 Claims. (Cl. 51—95)

This invention relates to grinding and lapping machines and more particularly to a machine for successively grinding and lapping of cylindrical work pieces.

One object of this invention is to provide a simple thoroughly practical cylindrical grinding and lapping machine. Another object is to provide an improved abrading machine for finishing cylindrical work pieces by first grinding the work piece and then lapping it to the desired size and finish without removing it from the machine. A further object is to provide a cylindrical grinding and lapping machine in which a rotatable grinding wheel and a rotatable lapping wheel are successively fed into operative engagement with the work to first grind and then lap the same. Another object is to provide a rotatable grinding wheel and a rotatable lapping wheel on opposite sides of a work piece, each of which is mounted on opposite ends of a carriage which is moved to successively present the grinding and lapping wheels to grind and then lap the work. A further object of this invention is to provide a feeding mechanism for successively feeding a rotatable grinding wheel and a rotatable lapping wheel to grind and then lap a work piece. A further object is to provide a hydraulic operated feeding mechanism to feed the wheels rapidly when out of contact with the work and a feed regulator to produce a slow uniform feed during the grinding and lapping operation.

Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combination of elements, and arrangements of parts as well as exemplified in the structure to be hereinafter described and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings, in which is shown one of various possible embodiments of the mechanical features of this invention,

Figure 1 is a perspective view of a combined cylindrical grinding and lapping machine embodying this invention;

Figure 2 is a vertical sectional view, on an enlarged scale, taken approximately on the line 2—2 of Figure 1, showing the grinding wheel and slide and lapping wheel and slide in elevation and the lower parts of the machine in sections;

Figure 3 is a cross-sectional view taken approximately on the line 3—3 of Figure 2 showing the work supporting table and the reciprocating mechanism therefor;

Figure 4 is a plan view, on an enlarged scale, of the lapping wheel slide having a cover removed to show the wheel spindle reciprocating mechanism and the gear box cut away and shown in section to more fully show the lapping wheel driving mechanism; and

Figure 5 is a sectional view taken approximately on the line 5—5 of Figure 4.

The improved combined cylindrical grinding and lapping machine has been illustrated in the drawings comprising a base 10 which supports a longitudinally reciprocable work table 11 on a V-way 12 and a flat way 13 formed on the base 10. The longitudinally movable work table 11 is provided with a rotatable work support comprising a headstock 14 and a footstock 15 which are provided with a headstock center 16 and a footstock center 17 respectively to rotatably support a cylindrical work piece 18 thereon.

Work rotating mechanism

The headstock 14 supports a rotatable headstock spindle 19 which carries a driving plate 20 at its inner end. The driving plate or face plate 20 is provided with a driving pin 21 which is arranged to engage either a projection on the work piece or a work driving dog clamped thereon. The headstock 14 and footstock 15 are preferably on the work table 11 to facilitate supporting and rotating work pieces of a desired length.

The headstock spindle 19 may be driven by any suitable means, such as, for example, as illustrated an electric motor 25 mounted on top of the headstock frame. The motor 25 is provided with an armature shaft 26 which carries a driving pulley 27. The driving pulley 27 is preferably of a multiple V-grooved type which is connected by a multiple V-belt 28 with a grooved pulley 29 mounted on the outer end of the headstock spindle 19.

To facilitate successively grinding and then lapping a work piece without removal of the same from the machine, it is desirable to provide a work driving mechanism which is of a variable speed type so that the work may be first rotated at a desired and predetermined speed for a grinding operation and then readily changed to a proper speed for a lapping operation. In the preferred form, the electric motor 25 is of a variable speed type which may be started and stopped by means of a push button 30 and the speed of which may be readily controlled by a rheostat 31. The push button 30 and rheostat 31 have

been illustrated as being mounted on the head-stock of the machine.

Manual table traverse

5 The work table 11 is arranged so that it may be moved longitudinally to position a work piece relative to the wheels by means of a manually operable traverse mechanism, such as, is old and well-known in the art. A manually operable traverse wheel 32, is mounted on the outer end of a rotatable shaft 33. The shaft 33 carries a gear 34 at its inner end which meshes with a gear 35 mounted on the outer end of a rotatable shaft 36. The inner end of the shaft 36 carries a gear 37 which meshes with a rack bar 38, depending from the work table 11. By rotation of the hand wheel 32, the table 11 may be traversed longitudinally to position the work piece 18 as desired.

Table reciprocating mechanism

20 The improved machine is arranged so that it may be utilized either for a traverse grinding and lapping operation or for a plunge-cut operation in which a wide face wheel of a width substantially equal to or slightly greater than the length of the portion of the work to be ground and lapped. In a plunge-cut operation, the work table 11 is positioned manually to locate the work piece in the desired relation with the wheel or wheels but remains stationary during the grinding and lapping operations.

30 In a traverse grinding and lapping operation for grinding and lapping a relatively long piece of cylindrical work, it is desirable to provide a table reciprocating mechanism for automatically reciprocating the table during the grinding and lapping operations. In the preferred form a fluid pressure operated table reciprocating mechanism is provided which for the sake of simplicity of illustration is substantially identical with that disclosed in the prior United States Patent No. 2,071,677 to W. H. Wood dated February 23, 1937 to which reference may be had for details of disclosure not found herein.

45 A fluid pressure cylinder 40 is supported at its opposite ends by brackets 41 and 42 respectively which are fixed to and depend from the underside of table 11. A piston 43 is slidably mounted within the cylinder 40 and is connected by a double end piston rod 44 which extends in opposite directions from the piston 43 and passes through the end caps or cylinder head at opposite ends of the cylinder 40 and is fastened to brackets 45 which are fixed to and located at opposite ends of the base 10 respectively.

50 Fluid under pressure is pumped from a reservoir 46 within the base 10 by means of a motor driven fluid pump 47 which draws fluid through a pipe 48 and forces fluid under pressure through a pipe 49 to a control valve unit 50 mounted within the base 10. The control valve unit comprises a reversing valve 51 and a speed control or throttle valve 52 which are identical with that shown in the U. S. Patent No. 2,071,677 above referred to and to which reference may be had for further details of disclosure.

65 The reversing valve 51 is controlled by a pivotally mounted reversing lever 55 supported on a stud 56 on the base 10. The reversing lever 55 is provided with an inwardly projecting pin 57 which is arranged in the path of adjustable table dogs 58 and 59 respectively which are arranged to actuate the reversing lever 55 and to thereby

reverse the direction of movement of the table 11 as desired.

5 The reversing lever 55 is provided with an adjustably mounted arrow point 60 at its lower end which is arranged to engage a spring pressed arrow pointed plunger 61 contained within the casing 62. The reversing valve 51 is connected as in the United States Patent No. 2,071,677 so that when the reversing lever 55 is moved by the dog 58 or the dog 59, the movement of the dog and table serves to shift the reversing valve to cut-off the flow of fluid to one of the cylinder chambers and fluid under pressure passing through the reversing valve serves to complete the reversal of the valve so as to change the direction of flow of fluid to and from the cylinder 40. Fluid under pressure passing through the valve 50 passes either through a pipe 63 or a pipe 64 into a cylinder chamber 65 or a cylinder chamber 66 respectively. In the preferred form, the piston rod 44 is hollow and fluid passing through the pipes 63 and 64, passes through the hollow piston rod 44 to the cylinder chambers 65 and 66 respectively. For further details of construction of the fluid pressure table actuated mechanism reference may be had to the above mentioned United States patent.

25 A pressure relief valve 67 is connected with the pipe 49 by a pipe 68 (Fig. 3). The relief valve 67 is preferably of the common well-known adjustable type which may be adjusted so that if the pressure within the fluid system exceeds a predetermined pressure, the valve opens and returns the excess fluid pressure into the reservoir 46.

Grinding and lapping wheels

35 In order that the work piece 18 may be successively ground and then lapped to produce a work piece of desired size and finish, a single abrasive wheel may be utilized for grinding and then lapping the work piece to the desired finish. In such a case, it is necessary to provide suitable means for slowing down the rotation of the grinding or abrasive wheel to a lapping speed. It has been found, however, that better results may be obtained both in the grinding operation and the lapping operation if separate abrasive wheel of the proper grit size and hardness is utilized for each operation. Therefore, to attain the main object of this invention, it is desirable to provide two independently adjusted and controlled wheel slides, namely a grinding wheel slide and a lapping wheel slide which are preferably arranged so that they may be moved successively into operative engagement with the work piece.

45 In the preferred form, two independent rotatably mounted abrasive wheels, one being utilized as a grinding wheel and rotated at a normal grinding speed, and the other being utilized as a lapping wheel and rotated at a speed below the normal grinding speed which is suitable for a lapping operation, are so mounted that they may be moved successively into operative contact with the work piece to first grind the same and then to lap the surface to the desired finish and size. In the preferred form the grinding wheel and the lapping wheel are rotatably mounted on independently adjustable slides which are in turn mounted upon a common slide or carriage, said wheels being arranged preferably to engage work piece on diametrically opposite sides. As illustrated in the drawing, a transversely movable wheel carriage 70 is mounted on a V-way 71 and a flat way 72 and is arranged to move trans-

versely relative to the work table 11. The carriage 70 extends through an aperture 73 in the base 10 beneath the work table ways 12 and 13 and extends transversely on either side of the work table 11.

Grinding wheel slide

A grinding wheel slide 74 carrying a rotatable grinding wheel 75 on a rotatable wheel spindle 76 is supported on a V-way 77 and a flat way 78 formed on the carriage 70. The grinding wheel 75 may be driven by a suitable driving mechanism, such as, an electric motor 80 mounted on top of the wheel slide 74. The motor 80 carries a driving pulley 81 which is preferably of the multiple V-groove type. The pulley 81 is connected by a multiple V-belt 82 with a multiple V-groove pulley 83 mounted on the wheel spindle 76. The motor 80 may be controlled by a push button 84 mounted on the wheel base 10 and which serves to start and stop the grinding wheel motor 80 and to rotate the same at a normal speed for grinding operation.

The wheel slide 74 is preferably arranged so that it may be adjusted longitudinally on the carriage 70. A feed wheel 87 of the well-known grinding wheel feeding mechanism, such as, is shown in the expired United States patent to Norton No. 762,838 dated June 4, 1904. The feed wheel 87 is mounted on a rotatable shaft 88 which is rotatably supported in bearings (not shown) in the carriage 70, a bevel gear 89 is mounted on the inner end of the shaft 88 and meshes with a bevel gear 90 mounted on the outer end of a rotatably mounted feed screw 91. The feed screw 91 is rotatably journaled in bearings within the carriage 70 and meshes with a half nut 92 depending from the wheel slide 74. A stop pawl 93 is pivotally mounted on a stud 94 on the transversely movable carriage 70 and is arranged to engage an abutment carried by a micrometer adjusting mechanism 95, to facilitate accurately adjusting the position of the grinding wheel in setting of the machine for a given operation or to be utilized to compensate for wheel wear.

Lapping wheel slide

A lapping wheel slide 100 is arranged to support a rotatable lapping wheel 101 which is supported on a wheel spindle 102, journaled within the slide 100. The lapping wheel slide 100 is arranged to be adjusted transversely relative to the work piece 18 on a V-way 103 and a flat way 104 formed on the transversely movable carriage 70.

The lapping wheel slide 100 is provided with a suitable driving mechanism which permits rotating the lapping wheel at a slow speed suitable for a lapping operation or which permits the wheel to be rotated at a relatively fast speed during a wheel truing operation. An electric motor 105 is mounted on top of the lapping wheel slide 100. The motor 105 is controlled by a push button 106 which permits the stopping and starting of the lapping wheel motor from the operator's control station.

The electric motor 105 drives a gear mechanism contained within a casing 107 which in turn rotates a multiple V-grooved pulley 108 and the grooved pulley 108 is connected by a multiple V-belt 109 with a multiple groove pulley 110 supported on the end of the wheel spindle 102.

The motor 105 is provided with an armature shaft 113 which rotatably supports a gear 114. The gear 114 meshes with a gear 115 mounted on the end of a shaft 116. The shaft 116 is provided with a worm 117 meshing with a worm

gear 118 on a vertically arranged shaft 119. The shaft 119 is provided with a worm 120 which meshes with a worm gear 121 rotatably supported on a shaft 122. The shaft 122 in turn supports the driving pulley 108. By utilizing the gear mechanism above described a very slow motion is transmitted from the motor shaft 113 to the driving pulley 108 and through the belt 109 and pulley 110 rotates the lapping wheel spindle 102 and the lapping wheel 101 at a slow rate of speed for a lapping operation. The shaft 122 has an enlarged end portion 123 which is cut out on its end to serve as a bearing support for the outer end of the armature shaft 113.

In order to true the lapping wheel 101, it is necessary to rotate it at a relatively fast rate of speed during the truing operation. To facilitate readily changing the speed of the lapping wheel 101 from a slow lapping speed to a fast truing speed, a manually operable clutch mechanism is provided. The end of the shaft 122 is provided with a clutch member 124 which is arranged to be engaged by a slidably mounted clutch member 125. A clutch member 125 is keyed to the armature shaft 113 and is arranged to be thrown into engagement with the clutch member 123 or to be thrown into engagement with a clutch member 126 formed integral with the gear 114. A slidably mounted clutch shifting member 127 is supported on a guide rod 128 and is provided with a yoked member having pins 129 arranged to ride in a groove 130 in the clutch member 125. A manually operable clutch lever 131 is pivotally mounted on a stud 132 and is arranged through a yoked member formed on its inner end which engages a pin on the clutch shifting member 127 so that when the lever 131 is moved in either direction, the clutch member 125 is shifted into engagement either with the clutch member 123 so that the armature shaft 113 drives directly to the shaft 122 to rotate the wheel spindle 102 and the lapping wheel 101 at a relatively fast speed suitable for a truing operation, or maybe thrown into engagement with the clutch teeth 126 which serves to transmit power from the armature shaft 113 through the gear reduction unit comprising the gear 114, the gear 115, the shaft 116, the worm 117, the worm gear 118, the shaft 119, the worm 120, the worm gear 121, to rotate the shaft 122 at a slow rate of speed which in turn rotates the wheel spindle 102 and the lapping wheel 101 at a relatively slow speed suitable for a lapping operation.

In order to stop the rotation of the reduction gear unit when the armature shaft 113 is connected directly with the driven shaft 122 for a truing operation, a clutch member 135 is slidably keyed to the shaft 122 and is arranged to be thrown out of engagement with clutch teeth 136 formed on the side face of worm gear 121.

The clutch shifting member 127 is provided with a second yoked member 137 having pins 138 which ride in a groove 139 in the clutch member 135 so that the clutch member 135 is moved simultaneously with the clutch member 125. When the clutch shifting member 127 is moved downwardly (Figure 4) to throw the clutch member 125 into engagement with the clutch teeth 126, the clutch member 135 is moved simultaneously in a downward direction to engage with the clutch teeth 136 carried by the worm gear 121 to lock the worm gear 121, to the shaft 122 so as to rotate shaft 122 at a slow rate of speed.

Similarly when the clutch shifting member 127 is moved in an upward direction (Figure 4), the

clutch member 125 is thrown out of engagement with the clutch teeth 126 and the clutch member 135 is thrown out of engagement with the clutch teeth 136 thereby rendering the reduction gear unit inoperative. Continued movement of the clutch shifting member 127 in an upward direction causes the clutch member 125 to be thrown into engagement with the clutch teeth 124 to connect the armature shaft 113 directly to the driven shaft 122. It will be readily apparent from the foregoing disclosure that by manipulation of the manually operable control lever 131, the motor 105 may be connected to rotate the lapping wheel spindle 102 and the lapping wheel 101 at a very slow speed for a lapping operation or may be readily shifted to rotate the wheel 101 at a relatively fast speed for a wheel truing operation.

Lapping wheel reciprocation

In a lapping operation, it may be desirable to provide an oscillating or reciprocating movement of the lapping wheel 101 when used in a plunge cut grinding operation to produce the desired break-up action between the lapping wheel and the surface of the work piece 18. This oscillation may also be utilized in a traverse grinding and lapping operation to supplement the relative traversing movement between the lapping wheel and the work piece. As illustrated in the drawing this mechanism may comprise a worm 150 which is mounted and driven by the lapping wheel spindle 102. The worm 150 meshes with a worm gear 151 carried by a vertical shaft (not shown), a crank plate 152 is mounted on the upper end of the shaft carrying the worm gear 151 and is connected by a connecting rod 153 with a stud 154 carried on the end of a rock arm 155 which is pivotally mounted on a stud 156 on the wheel slide frame. The lever 155 is connected by stud 157 with a groove 158 formed between sleeve fixed on the wheel spindle and the end of the worm 150, so as to transmit the motion of the crank 152 through the rock arm 155 to oscillate the wheel spindle 102 as it rotates. A manually operable lever 159 serves to swing the lever 155 and to lock it against oscillation, and serves to readily start and stop the oscillation or reciprocation of the lapping wheel spindle as desired.

The lapping wheel slide 100 is provided with a manual adjustment for adjusting it longitudinally on the carriage 70. A feed wheel 160 of the well-known grinding wheel feeding mechanism type such as is shown in the above mentioned expired United States Patent No. 762,838. The feed wheel 160 is mounted on a rotatable shaft 161 which is rotatably supported in bearings (not shown) in the carriage 70. A bevel gear 162 is mounted on the inner end of the shaft 161 and meshes with a bevel gear 163 mounted on one end of a rotatable feed screw 164. The feed screw 164 is journaled in suitable bearings in the carriage 70 and is arranged to engage and mesh with a depending half nut 165 fixed to the underside of the lapping wheel slide 100. A stop pawl 166 is pivotally mounted on a stud 167 is arranged in the path of an abutment (not shown) carried by a micrometer feed adjustment 168. By manipulation of the feed wheel 160, the lapping wheel 101 and its supporting wheel slide 100 may be readily adjusted relative to the transversely movable carriage 70 in setting up the machine for a given operation and may also be utilized to compensate for wear of the lapping wheel.

Grinding and lapping feed

The carriage 70 is provided with a feeding mechanism which is arranged so that by movement of a control lever the grinding wheel slide 74 and grinding wheel 75 may be moved rapidly toward the work piece and then fed at a slow rate of infeed during the grinding operation after which the manipulation of the control lever operates to feed the slide 70 in the reverse direction to move the grinding wheel slide 74 and grinding wheel 75 away from the work piece at a rapid rate and at the same time advance the lapping wheel 101 and its supporting wheel slide 100 rapidly toward the work piece. The rapid approaching movement of the lapping wheel 101 continues until it is about to engage the work after which the infeed is reduced to a slow uniform infeed for a lapping operation. This mechanism may be operated automatically to grind for a definite time interval and to then automatically reverse to lap the work piece. As shown in the drawings, however, a manually controlled feeding mechanism is provided of the hydraulic type comprising a cylinder 180 which is fixed within the base 10 of the machine. A piston 181 is slidably mounted within the cylinder 180 and is connected by a piston rod 182 with a bracket 183 which is either fixed to or formed integral with the carriage 70.

As shown in the drawings an independent fluid pressure system is provided for moving the work table 11 and for moving the carriage 70.

A reservoir 184 is provided within the base 10 of the machine. A motor driven pump 185 draws fluid through a pipe 186 from the reservoir 184 and forces fluid under pressure through a pipe 187 to a control valve 188. The control valve 188 is preferably a piston type valve comprising a valve stem 189 having a plurality of valve pistons formed integrally therewith which form valve chambers 190, 191 and 192. In the position of the parts as illustrated in Figure 2, fluid under pressure passing through the pipe 187 enters the valve chamber 191 and passes through a passage 193 into a cylinder chamber 194 to cause the piston 181 to move toward the left (Figure 2). During this movement of the piston, fluid within a cylinder chamber 195 is forced out through a passage 196 into the valve chamber 192 and through a pipe 197 which exhausts into the reservoir 184.

The valve stem 189 is preferably arranged so that it may be manually operated from the operator's control station. A manually operated control lever 200 is mounted on the outer end of a rotatable shaft 201 which is rotatably supported in suitable bearings in the base 10 of the machine. The inner end of the shaft 201 is provided with a yoke member 202 having pins 203 which ride within a groove 204 in a spool-shaped member 205 mounted on the end of the valve stem 189. The lever and valve as shown in Figures 1 and 2 are in position to start an infeeding movement of the grinding wheel. After the grinding operation is completed the control lever 200 is rocked in a counter-clockwise direction (Figure 1) which serves to shift the valve stem 189 toward the right (Figure 2) to reverse the flow of fluid to the cylinder 180. When the valve is shifted toward the right, fluid under pressure passing from the pipe 187 into the valve chamber 191 passes through the passage 196 into the cylinder chamber 195 to cause the piston 181 and the carriage 70 to move toward the right (Figure 2) to cause the grinding wheel 75 to rapidly

move away from the surface of the work being ground and at the same time causes the lapping wheel 101 to rapidly approach the work piece for a lapping operation.

- 5 A pressure relief valve 206 is provided in the pipe line 187 and serves in case the pressure in the pipe line exceeds a predetermined pressure to allow the excess fluid under pressure to exhaust through a pipe 207 to the reservoir 184.
- 10 While in the drawings two independent fluid pressure systems have been illustrated for simplicity of illustration, a single reservoir may be employed and a motor driven double geared pump unit may be substituted for the pumps 47
- 15 and 185 which may be driven from a single pump drive motor.

- In the mechanism above described, namely, the cylinder 180 and piston 181 as controlled by the manually operable control lever 200 and the valve 188 serves to cause a rapid movement of the wheel carriage 70 in either direction. In order to grind the work and then lap the work, it is desirable to provide a feed regulator which as illustrated comprises a hydraulic feed regulator such as a dash pot piston and cylinder.
- 25 A dash pot piston and cylinder of the type shown and described in the United States Patent No. 2,023,704 to H. A. Silven dated December 10, 1935 has been illustrated in the present case.
- 30 Reference may be had to this prior patent for a detailed disclosure of the construction and operation of this mechanism. A dash pot cylinder 210 is mounted on the right-hand cylinder head so that the dash pot piston 211 is slidably mounted therein and is also slidably mounted on the piston rod 182. The dash pot piston 211 is normally held in a position toward the right by means of a spring 212. When fluid and the pressure is admitted to the cylinder chamber 194
- 40 to cause a rapid approaching movement of the grinding wheel 75, this rapid approaching movement continues until an adjustable sleeve 213 carried by the piston rod 182 engages the end of the dash pot piston 211. The rapid approaching
- 45 movement of the grinding wheel 75 is thereafter reduced to a slow uniform grinding feed by resistance encountered in exhausting oil from the dash pot cylinder through an adjustable needle valve so that the desired grinding feed may
- 50 be readily obtained. The infeeding movement of the grinding wheel continues until an adjustable stop sleeve 214 engages the end surface of the dash pot cylinder head to thereby positively limit the approaching feed of the slide 74 and the
- 55 grinding wheel 75.

- A similar hydraulic feed regulator is mounted on the left-hand cylinder head to slow down the rapid approaching movement of the lapping wheel 101 to a desired slow speed as the lapping wheel approaches the work piece 18. This mechanism comprises a dash pot cylinder 215 fixedly mounted to the left-hand cylinder head (Figure 2). A dash pot piston 216 is slidably mounted within the dash pot cylinder 215 and is also
- 60 slidably mounted on the piston rod 182. A spring 217 serves to normally hold the dash pot piston 216 in its end position toward the left (Figure 2). The rapid approaching movement of the lapping wheel 101 continues until an adjustable sleeve 218 mounted on the piston rod
- 70 182 engages the end face of the dash pot piston 216. Continued approaching movement is thereby reduced to a slow feeding movement due to the fact that the fluid within the dash pot
- 75 chamber must exhaust through an adjustable

needle valve, thereby retarding the rapid movement caused by the piston 181 to produce a slow feed of the lapping wheel 101. The lapping wheel approaches the work piece 18 until a positive stop sleeve 219 which is adjustably fixed on the sleeve 218 engages the end face of the dash pot cylinder head to positively limit the movement of the wheel carriage 70 toward the right (Fig. 2).

If desired in operation of this machine, the hydraulic feed regulator on either end of the cylinder 180 may be rendered ineffective by adjustment of the sleeves 213 and 218 and the adjustable stops 214 and 219, respectively. If desired the grinding wheel may be caused to rapidly approach the work piece until the positive stop 214 engages the end of the cylinder head and similarly the lapping wheel may be caused to rapidly approach the surface of the work piece 18 until the adjustable stop 219 engages the end of the dash pot cylinder 215. This operation involving merely adjustments of the respective parts so that the adjustable stop engages the end of the cylinder head prior to the stop sleeve engaging the end of the dash pot piston.

It will be readily apparent from the foregoing disclosure that the grinding and lapping wheel carriage 70 may be readily caused to move in either direction to first position the grinding wheel 75 in operative contact with the work piece for either a plunge cut or a traverse grinding operation and thereafter by shifting the control lever 200 in a counter-clockwise direction (Figure 1) first to cause the grinding wheel 75 and its supporting slide 74 to move away from the work piece, and the lapping wheel 101 and its supporting slide 100 to move rapidly into an operating position in engagement with the work piece 18 to lap the same.

The operation of this machine will be readily apparent from the foregoing disclosure. A work piece 18 to be ground and lapped is mounted on the work supporting centers 16 and 17 between the footstock 14 and 15. The work piece is then set in rotation by the push button 30 and the speed of the work adjusted by means of a rheostat 31 to cause the work to rotate first at a grinding speed. If, as shown in the drawings, a piece of work is to be ground requiring a traverse grinding operation, the work table 11 is then set in motion by manipulation of the control valve 52 and the reverse control lever 55. The lever 200 is then moved into the position as shown in Figure 1 to cause the wheel carriage 70 to be moved toward the left, Figures 1 and 2, to move the grinding wheel 75 toward the work piece for a cylindrical grinding operation thereon. The grinding operation is continued until the work piece 18 has been ground to the desired extent, after which the control lever 200 is shifted in a counter-clockwise direction to reverse the position of the control valve 188 and thereby cause the wheel carriage 70 to move toward the right (Figures 1 and 2) to rapidly move the grinding wheel 75 away from the work and to cause a rapid approaching movement of the lapping wheel 101. During this movement the rheostat 30 may be adjusted to change the speed of the work to a proper speed for a lapping operation. The lapping operation may then proceed to the desired extent after which the control lever 200 may be moved into a grinding position to separate the lapping wheel 101 from the work, after which it may be moved into a central or neutral

position to stop the movement of the wheel carriage during removal of the finish ground and lapped piece of work. If it is desired to oscillate the lapping wheel 101 during the lapping operation, the lever 159 may be actuated to start the oscillation of the lapping wheel spindle. If desired, the hydraulic feed mechanism for the grinding wheel carriage may be utilized merely as a positioning movement, in which case the adjustable stops 214 and 219, respectively, are adjusted to stop the rapid approaching movement either when or just before the grinding wheel 75 and the lapping wheel 101 engage the work piece 18, after which the manually operable feed wheels 87 and 160 may be utilized to produce the desired infeeding movement during the grinding, and later, during the lapping operation.

It will thus be seen that there has been provided by this invention apparatus in which the various objects herein above set forth, together with many thoroughly practical advantages, are successfully achieved. As many possible embodiments may be made of the above invention and as many changes might be made in the embodiment above set forth, it is to be understood that all matter herein before set forth, is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. A grinding and lapping machine having a base, a longitudinally movable work supporting table, a rotatable work support thereon, means to rotate said work support at either a grinding or a lapping speed, a transversely movable carriage, a rotatable grinding wheel thereon, means to rotate said wheel at a normal grinding speed, a rotatable lapping wheel on said carriage, means to rotate said lapping wheel at a relatively slow lapping speed and a carriage feeding mechanism to move said carriage transversely in either direction successively to move the grinding wheel and the lapping wheel into operative engagement with the work successively to grind and lap the same.

2. A grinding and lapping machine having a base, a longitudinally reciprocable table thereon, a rotatable work support on said table, means to rotate said support at either a grinding or a lapping speed, a transversely movable carriage on said base, a rotatable grinding wheel adjustably mounted on said carriage, means to rotate said wheel at a normal grinding speed, a rotatable lapping wheel adjustably mounted on said carriage, means to rotate said lapping wheel either at a relatively slow lapping speed or at a relatively fast speed for a truing operation, and a carriage feeding mechanism operative to move said carriage transversely in either direction to successively move the grinding wheel and the lapping wheel into operative engagement with the work to grind and lap the same.

3. A grinding and lapping machine having a rotatable work support thereon, means to rotate said work support at either a grinding or a lapping speed, a transversely movable carriage, a rotatable grinding wheel thereon, means to rotate said grinding wheel at a normal grinding speed, a rotatable lapping wheel on said carriage, means to rotate said lapping wheel at a relatively slow lapping speed, said grinding and lapping wheels being arranged successively to engage opposite sides of the work piece, and a carriage feeding mechanism to move said carriage transversely in either direction successively to move the grinding wheel and the lapping wheel into

operative engagement with the work to grind and lap the same.

4. A grinding and lapping machine having a base, a rotatable work support thereon, means to rotate said work support at either a grinding or a lapping speed, a transversely movable carriage on said base, a rotatable grinding wheel thereon, means to rotate said wheel at a normal grinding speed, a rotatable lapping wheel on said carriage, means independently to rotate said wheel at a relatively slow lapping speed, a carriage feeding mechanism including a fluid pressure operated piston and cylinder operatively connected to move said carriage transversely in either direction to successively move the grinding wheel and lapping wheel into operative engagement with the work to successively grind and lap the same.

5. A grinding and lapping machine having a base, a longitudinally movable table, a rotatable work support thereon, means to rotate said work support at either a grinding or a lapping speed, a transversely movable carriage, a rotatable grinding wheel thereon, means to rotate said wheel at a normal grinding speed, a rotatable lapping wheel on said carriage, independent means to rotate said wheel at a relatively slow lapping speed, a carriage feeding mechanism comprising a fluid pressure operated piston and cylinder operatively connected to move said carriage transversely in either direction, and means including a hydraulic feed regulator to control the grinding and lapping feed and to control the final positions of said grinding and lapping wheels.

6. A grinding machine having a base, a longitudinally reciprocable table thereon, a rotatable work support on said table, a transversely movable carriage, a rotatable grinding wheel adjustably mounted on said carriage, means to rotate said grinding wheel at a normal grinding speed, a rotatable lapping wheel adjustably mounted on the carriage, means to rotate said lapping wheel at a relatively slow lapping speed, said grinding and lapping wheels being arranged to be moved successively into engagement with said work piece, a carriage feeding mechanism including a fluid pressure operated piston and cylinder interposed between the carriage and base, means including a manually operable valve to control the admission of fluid under pressure to said cylinder to move the carriage transversely in either direction so as to successively move the grinding and lapping wheels into operative engagement to successively grind and lap a work piece, an adjustable positive stop operatively connected to limit the infeeding movement of said grinding wheel, and a second adjustable stop which is arranged to limit the infeeding movement of said lapping wheel when the carriage is moved in the opposite direction.

7. A grinding machine having a base, a longitudinally reciprocable work table, a rotatable work support thereon, means to rotate said work support to rotate the work piece either at a grinding or a lapping speed, a transversely movable carriage on said base, a rotatable grinding wheel adjustably mounted on said carriage, means including an electric motor to rotate said wheel at a grinding speed, a rotatable lapping wheel adjustably mounted on said carriage, means including an electric motor and a gear reduction unit to rotate said wheel at a lapping speed, said grinding and lapping wheels being arranged to successively engage said work piece to first grind

and then lap said work piece, a carriage feeding mechanism therefor including a fluid pressure operated piston and cylinder operatively connected to move said carriage, a manually operable control valve to control the admission of fluid to said cylinder and cause said carriage to move in either direction, a feed regulator to arrange to modify the carriage movement as the grinding wheel engages the work, to produce a grinding feed, and a second feed regulator which is operative when said carriage moves in the opposite direction to regulate the infeeding movement of said lapping wheel.

8. A grinding and lapping machine having a longitudinally reciprocable table thereon, a rotatable work support on said table, a transversely movable carriage on said base, a rotatable grinding wheel adjustably mounted on said carriage, means to rotate said wheel at a normal grinding speed, a rotatable lapping wheel adjustably mounted on said carriage, means to rotate said lapping wheel at a relatively slow lapping speed, said grinding and lapping wheels being arranged successively to engage the work piece on diametrically opposite sides, a carriage feeding mechanism therefor, including a fluid pressure operated piston and cylinder, a manually operable control valve therefor to cause a rapid approaching movement of the carriage in either direction, a hydraulic feed regulator arranged to reduce the rapid approaching movement to a slow grinding feed when the grinding wheel is moved into operative engagement with the work piece, and a second hydraulic feed regulator which is arranged to reduce the rapid approaching feed to a relatively slow infeeding movement of the lapping wheel as the lapping wheel is moved into operative engagement with the work piece.

9. A grinding machine having a longitudinally movable, rotatable work support, a transversely movable carriage, a wheel slide movable longitudinally on said carriage, means to adjust said slide longitudinally on said carriage, a rotatable grinding wheel supported thereon, a lapping wheel slide adjustable longitudinally on said carriage, means to adjust said lapping wheel slide longitudinally on said carriage, a rotatable lapping wheel supported thereon, said grinding and lapping wheels and slides being arranged to successively engage a work piece on opposite sides thereof, a carriage feeding mechanism therefor including a fluid pressure operated piston and cylinder operatively connected to move said carriage rapidly in either direction, a hydraulic wheel feed regulator associated with said cylinder and arranged to reduce the rapid approaching movement to a relatively slow grinding feed as the grinding wheel approaches the work piece, and a second hydraulic feed regulator associated with said piston and cylinder and arranged to slow down the rapid approaching movement of the lapping wheel when it moves into engagement with the work piece.

10. A grinding machine having a longitudinally movable, rotatable work support, a transversely movable carriage, a rotatable grinding wheel adjustably mounted thereon, a rotatable lapping wheel adjustably mounted on said carriage, said grinding and lapping wheels being arranged to successively engage the work piece on diametrically opposite sides thereof, and a carriage feeding mechanism therefor including a fluid pressure operated piston and cylinder operatively connected to move said carriage rap-

idly in either direction, a manually operable control valve to cause a rapid movement of the carriage in either direction, a hydraulic feed regulator which is arranged to reduce the rapid approaching movement to a relatively slow grinding feed when the grinding wheel approaches and engages the work piece, and a second hydraulic feed regulator which is arranged to reduce the rapid approaching movement to a slow infeeding movement when the carriage moves in the opposite direction as the lapping wheel engages the work piece.

11. A grinding machine having a longitudinally movable, rotatable work support, transversely movable carriage, a rotatable grinding wheel adjustably mounted on this carriage, a rotatable lapping wheel adjustably mounted on said carriage, said grinding and lapping wheels being arranged to successively engage opposite sides of a work piece, and a carriage feeding mechanism therefor, including a fluid pressure piston and cylinder to move said carriage transversely in either direction, a manually operable control valve to control the admission of fluid under pressure to said cylinder to cause a rapid movement of the carriage in either direction, a dash-pot mechanism at one end of said cylinder to reduce the rapid approaching movement to a relatively slow grinding feed, and when the carriage is moved in one direction, and a second dash-pot mechanism which is arranged to slow down the rapid approaching movement of the lapping wheel to a relatively slow feed as when the lapping wheel engages the work piece.

12. A feeding mechanism for a transversely movable slide comprising a fluid pressure piston and cylinder operatively connected to move said slide, a manually operable control valve to control the admission of fluid under pressure to said cylinder to move slide rapidly in either direction, a feed regulator to produce a relatively slow feeding movement of the slide when moved in one direction, and a second feed regulator to produce a relatively slow feeding movement of the slide when it moves in the opposite direction.

13. A feeding mechanism for a transversely movable slide comprising a fluid pressure piston and cylinder operatively connected to move said slide, a control valve to control the admission of fluid under pressure to said cylinder so as to move the slide rapidly in either direction, a hydraulic feed regulator to produce a relatively slow feeding movement of the slide during its movement in one direction and a second hydraulic feed regulator to produce a relatively slow feeding movement of the slide during its movement in the opposite direction.

14. A feeding mechanism for a transversely movable slide comprising a fluid pressure piston and cylinder operatively connected to move said slide, a manually operable control valve to control the admission of fluid under pressure to said cylinder to move the slide rapidly in either direction, a hydraulic feed regulator located adjacent to one end of said cylinder and arranged to produce a relatively slow feeding movement of the slide during its movement in one direction, and a second hydraulic feed regulator located adjacent to the other end of said cylinder, and arranged to produce a relatively slow feeding movement of the slide during its movement in the opposite direction.

15. A grinding wheel feeding mechanism for a transversely movable slide comprising a fluid pressure piston and cylinder operatively connect-

- ed to move said slide, a manually operable control valve to control the admission of fluid under pressure to said cylinder to move the slide rapidly in either direction, a hydraulic feed regulator located adjacent to one end of said cylinder which is arranged to slow down the rapid approaching movement to a relatively slow feeding movement, an adjustable positive stop associated therewith to limit the infeeding movement of said slide, a second hydraulic feed regulator located adjacent to the other end of said cylinder and arranged to slow down the rapid approaching movement to a relatively slow feeding movement when the slide moves in the opposite direction.
- 15 16. A grinding wheel feeding mechanism for a transversely movable slide comprising a fluid pressure piston and cylinder operatively con-

nected to move said slide in either direction, a manually operable control valve to control the admission of fluid to said cylinder so as to move the slide rapidly in either direction, a hydraulic feed regulator located at one end of said cylinder and arranged to produce a relatively slow feeding movement after the slide reaches a predetermined position, a positive stop to limit said infeeding movement, a second hydraulic feed regulator located adjacent to the other end of said cylinder and arranged to reduce the rapid approaching movement of said slide to a relatively slow infeeding movement when the slide moves to a predetermined position in the opposite direction, and positive stop to limit the infeeding movement.

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